IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant	:	Daniel Stearns et al.	Attorney Docket: CIL-10843
Serial No.	:	09/896,722	Art Unit: 1765
Filed	:	June 29, 2001	Examiner: R. Kunemund
For	:	A Method To Repair Localized Amplitude Defects In A EUV Lithography Mask Blank	

FEE AUTHORIZATION FOR FILING A BRIEF IN SUPPORT OF APPEAL UNDER 37 CFR 1.17(c)

The fee required for filing a Brief in support of an appeal is **$330.**

The Commissioner is hereby authorized to deduct the required fee **($330.)** from Deposit Account 501913.

Respectfully submitted,

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Dated: September 27, 2004

PATENT

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BRIEF ON APPEAL

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This is an appeal to the Board of Patent Appeals and Interferences from the final rejection of Claims 1-25 and 36 mailed October 31, 2003. On April 27, 2004, a timely Notice of Appeal was filed.

I. REAL PARTIES IN INTEREST

The real parties in interest are the EUV LLC, the Regents of the University of California and the United States of America as represented by the United States Department of Energy.

II. RELATED APPEALS AND INTERFERENCES

Appellant knows of no other appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-25 and 36 are pending on appeal and stand rejected. A copy of the claims on appeal are set forth in Appendix I.

IV. STATUS OF AMENDMENTS

All prior amendments have been entered.

V. SUMMARY OF INVENTION

The EUV lithography mask blank consists of a thick substrate coated with a reflective multilayer film. A particle imbedded near the top of the coating, or a pit or scratch that damages the coating near the top surface, attenuates the EUV light and can significantly reduce the local reflectivity of the mask. When such a feature produces an unacceptable intensity modulation in the lithographic image, it is considered to be an amplitude defect. The present invention is a method to repair an amplitude defect in the multilayer coating. The invention exploits the fact that a significant number of layers underneath the amplitude defect are undamaged. The repair method restores the local reflectivity of the coating by physically removing the defect and leaving a wide, shallow crater that exposes the underlying intact layers.

The repair method consists of first removing the particle (if a particle exists) and secondly etching away the damaged region of the multilayer coating without disturbing the intact underlying layers. The particle is removed by milling using a high-resolution focused ion beam (FIB) operating near normal incidence and having a diameter less than 100 nm. The FIB has a gas source (consisting of, for example, He, Ne, Ar, Xe, F, Cl, I, Br), or a liquid metal source (consisting of, for example, Ga). The FIB is also used for imaging the defect during the repair process. The removal of the particle leaves a hole in the surface of the multilayer coating, with collateral damage in the vicinity of the hole due to implantation and redeposition. In the second step of the repair, the damaged part of the coating is removed by etching using a low-voltage (<

5000 V) ion beam at a low angle of incidence (< 20 degrees from the coating surface). This could be the same FIB that is used to remove the particle or a second ion beam. In this step the ion beam can be relatively large (up to 1 mm diameter) and can be rotated with respect to the mask to improve the uniformity of the etching process. The low-voltage, low-angle beam configuration is important because it does not significantly heat the coating during the repair process (the temperature is kept below 200 °C) and produces minimal damage at the surface. The result of the repair method is to replace the amplitude defect with a wide (10 μm - 1 mm-diameter), shallow (typically < 150 nm-depth) crater at the surface of the reflective multilayer coating that exposes the underlying intact layers and thereby restores the local reflectivity.

In addition to a FIB, it is possible that other tools may be used to remove the particle and produce a suitable crater in the multilayer coating. For example, there is a relatively new tool produced by Rave LLC and commercially available for the repair of absorber layers in patterned masks; this tool is similar to an Atomic Force Microscope but it has the capability to produce a crater of similar size and shape (in the multilayer coating) to that required by this invention. This tool could be used for both imaging the defective area and producing the crater.

This invention has the potential to impact the extreme ultraviolet lithography (EUVL) system currently under joint development between Lawrence Livermore National Laboratory(LLNL), Sandia National Laboratory, Lawrence Berkeley Laboratory and the EUV Limited Liability Company which consists of a consortium of

companies in private industry. In addition to strong commercial applications, EUVL has the potential to impact government programs such as ASCII.

There is a strong commercial driving force for increased miniaturization in electronic devices, and hence an extreme ultraviolet lithography (EUVL) tool has significant commercial potential. To be economically viable this technology requires a nearly defect-free reflective reticle. Commercial integrated circuit manufacturers currently rely on defect repair techniques to obtain transmission reticles with sufficiently low defect densities; however, these repair techniques cannot be applied to the reflective EUVL reticles. The invention described here is a technique to repair defects in reflective EUVL reticles.

VI. ISSUE

Whether claims 1-25 and 36 are unpatentable over Thilderkvist et al. in view of Montcalm et al.

VII. GROUPING OF CLAIMS

Claim 1 is separately patentable from claims 2 and 25. Claims 2 and 25 stand or fall together. Claims 3-24 and 36 stand or fall together.

VIII. ARGUMENT

Are claims 1-25 and 36 unpatentable over Thilderkvist et al. in view of Montcalm et al?

In Thilderkvist et al., a contaminated surface of a substrate processing chamber is coated with a layer of a material such that the contaminants are collected by the layer of material. A portion of the layer together with a portion of the contaminants is then removed. In the reference, the "surface" refers to "parts in a processing chamber such as a susceptor, wafer lift pins, or any other surfaces that will be in either direct or close contact with the wafer during processing". See column 3, lines 40-47. The reference does not disclose a step of ***removing a defect*** that is causing an amplitude defect ***from a multilayer coating***, as recited by the applicants in claims 1 and 25. Emphasis added. The reference also fails to teach the step of etching away the damaged region. Claims 2 and 25 include the limitation that the damaged region is removed without disturbing the intact underlying layers of the multilayer coating.

In Montcalm et al., a passivating overcoat bilayer is used for multilayer reflective coatings for extreme ultraviolet (EUV) or soft x-ray applications to prevent oxidation and corrosion of the multilayer coating, thereby improving the EUV optical performance. The overcoat bilayer comprises a layer of silicon or beryllium underneath at least one top layer of an elemental or a compound material that resists oxidation and corrosion. Materials for the top layer include carbon, palladium, carbides, borides, nitrides, and oxides. The thicknesses of the two layers that make up the overcoat bilayer are optimized to produce the highest reflectance at the wavelength range of operation. Protective overcoat systems comprising three or more layers are also possible. There is no discussion in the reference of ***removing a defect*** that is causing an amplitude defect ***from a multilayer coating***, as recited by the applicants in claim 1. Emphasis added. The

reference also fails to teach the step of etching away the damaged region. Thus, the combination of references will not result in the applicant's invention. Therefore the rejection of claims 1 and 25 should be withdrawn. The rejection of claims 2-24 and 36 should be withdrawn because they depend from claim 1. Therefore the rejection should be withdrawn.

Why the appellant believes claim 1 is separately patentable from claims 2 and 25.

Claim 1 recites a method for repairing an amplitude defect in a multilayer coating, comprising removing a defect that is causing the amplitude defect from the multilayer coating. The combination of references fails to teach the removal of an amplitude defect from a multilayer coating. Claims 2 and 25 include the limitation that the damaged region is removed without disturbing the intact underlying layers of the multilayer coating. The combination of references fails to teach the removal of a damaged region of a multilayer coating without disturbing the intact underlying layers of the multilayer coating.

Accordingly it is submitted that the rejections of Claims 1-25 and 36 under 35 U.S.C. § 103(a) are improper and should be reversed.

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IX APPENDIX I

1. A method for repairing an amplitude defect in a multilayer coating, comprising:

removing a defect that is causing said amplitude defect from said multilayer coating, wherein said defect is selected from the group consisting of a particle, a shallow pit and a scratch, wherein a damaged region of said multilayer coating will remain after removal of said defect; and

etching away said damaged region.

2. The method of claim 1, wherein the step of etching away said damaged region is carried out without disturbing the intact underlying layers of said multilayer coating.

3. The method of claim 1, wherein the step of removing a particle includes milling said particle out of said multilayer coating.

4. The method of claim 3, wherein the step of milling is carried out with a focused ion beam (FIB).

5. The method of claim 4, wherein said FIB is operated near normal incidence.

6. The method of claim 4, wherein said FIB has a diameter less than 100 nm.

7. The method of claim 4, wherein said FIB comprises a gas source.

8. The method of claim 7, wherein said gas source comprises a gas selected from the group consisting of He, Ne, Ar, Xe, F, Cl, I and Br.

9. The method of claim 4, wherein said FIB comprises a liquid metal source.

10. The method of claim 9, wherein said liquid metal source comprises a liquid metal selected from the group consisting of Ga, Si, In, Pb and Hg.

11. The method of claim 4, further comprising imaging said defect with said FIB.

12. The method of claim 1, further comprising imaging said defect during the step of removing and the step of etching.

13. The method of claim 12, wherein the step of imaging is carried out using a focused ion beam.

14. The method of claim 1, wherein the step of etching away said damaged region is carried out using an ion beam having a voltage of less than 5000 V.

15. The method of claim 14, wherein said ion beam has a diameter within the range from about 10 nm to about 1 mm.

16. The method of claim 14, wherein said ion beam is rotated with respect to said multilayer coating to improve the uniformity of the etching process.

17. The method of claim 1, wherein the step of etching away said damaged region is carried out at a temperature less than 200 °C.

18. The method of claim 1, wherein the step of etching away said damaged region produces a crater in the surface of said multilayer coating that has a diameter of greater than 10 μm and a depth of less than 150 nm.

19. The method of claim 1, wherein the step of etching away said damaged region is carried out using an ion beam at an angle of incidence that is less than 20 degrees from the surface of said multilayer coating.

20. The method of claim 19, wherein said ion beam is rotated with respect to said multilayer coating to improve the uniformity of the etching process.

21. The method of claim 4, further comprising removing atoms implanted by milling step to remove defect

22. The method of claim 1, wherein said particle is on the top of, or imbedded near the surface of, said multilayer coating, surrounded by a localized region of damaged multilayer coating.

23. The method of claim 1, further comprising minimizing the slope of the surface of said multilayer coating in the repaired region.

24. The method of claim 1, further comprising depositing a Si layer subsequent to the step of removing a defect, wherein said Si layer is about 1 to 4 nm thick, wherein said Si layer limits oxidation of the exposed multilayer coating.

25. A method for repairing an amplitude defect in a multilayer coating, comprising physically removing the defect from said multilayer coating and leaving a wide, shallow crater that exposes the underlying intact layers to restore the local reflectivity of the coating.

36. The method of claim 1, wherein the step of removing a defect is carried out with an Atomic Force Microscope (AFM) having the capability to produce a crater.